

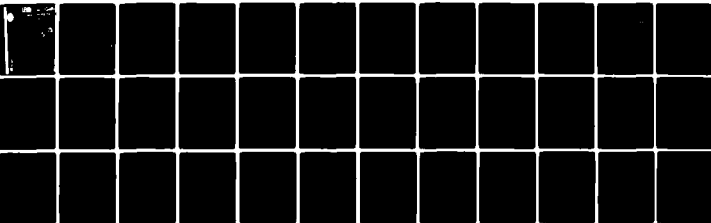
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JOHNS HOPKINS UNIV BALTIMORE MD DIV OF BEHAVIORAL BIOLOGY F/G 5/10
EXPERIMENTAL ANALYSIS OF SMALL-GROUP PERFORMANCE EFFECTIVENESS:--ETC(U)
NOV 80 J V BRADY, H H EMURIAN N00014-77-C-0498

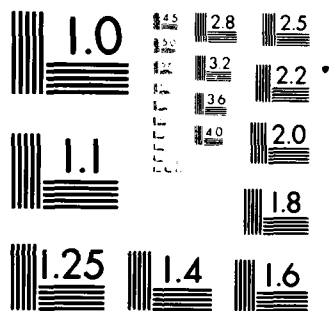
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Summarized herein are the results of a three-year research program, encompassing the period from 1 July 1977 through 30 June 1980, that focused upon an experimental analysis of the interacting motivational and social factors which influence performance effectiveness in small groups under conditions of continuous residence and observation in a closed ecological environment. Studies were conducted with three-person groups of human volunteers over extended periods in		

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a residential laboratory which provided for programmable work and recreational opportunities within the context of a biologically and behaviorally supportive environmental setting. Investigative emphasis was directed toward (1) the motivational effects on team participants produced by the programmed consequences of individual and group work tasks, and (2) the impact on established and novitiate team participants of a change in group composition and size. Performance effectiveness was evaluated in terms of group productivity and individual accuracy on a multiple-task-performance-battery developed during the course of the research program. The significance of these investigative endeavors is to be understood in terms of the emerging motivational and social-interaction principles having practical relevance to the establishment and maintenance of operational team performance effectiveness ←

FINAL REPORT

to

Organizational Effectiveness Research Programs
Department of The Navy
800 N. Quincy St.
Arlington, Va. 22217

Title: Experimental Analysis of Small-Group Performance Effectiveness:
Motivational Factors and Social Interactions.

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Period: 1 July 1977 to 30 June 1980

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PROJECT REVIEW

The three-year research program encompassing the period from 1 July 1977 through 30 June 1980 focused upon an experimental analysis of the interacting motivational and social factors which influence performance effectiveness in small groups under conditions of continuous residence and observation in a closed ecological environment. Studies were conducted with three-person groups of human volunteers over extended periods in a residential laboratory which provided for programmable work and recreational opportunities within the context of a biologically and behaviorally supportive environmental setting. Investigative emphasis was directed toward (1) the motivational effects on team participants produced by the programmed consequences of individual and group work tasks and (2) the impact on established and novitiate team participants of a change in group composition and size. Performance effectiveness was evaluated in terms of group productivity and individual accuracy on a multiple-task-performance-battery developed during the three-year contract period.

RESEARCH OBJECTIVES

(1) To undertake an experimental analysis of group performance effectiveness under the interacting motivational and social conditions generated by the programmed consequences of skilled work.

(2) To investigate biochemical correlates of behavior as they relate to the development of more sensitive indicators of variations in

mission task performance, group composition and interpersonal adjustment.

(3) To study organizational structure-function relationships and performance effectiveness under conditions of a change in group size and membership.

RESEARCH PROGRESS

The results obtained in the course of the series of small group performance effectiveness studies conducted over the past three years on ONR Research Contract N00014-77-C-0498 have been summarized in the twelve Quarterly Status Reports submitted from 1 July 1977 to 30 June 1980. Four detailed Technical Reports have also been prepared describing the work accomplished on this contract over the past three years (see Technical Report 1, entitled "Behavioral Analysis of Motivational and Emotional Interactions in a Programmed Environment"; Technical Report 2, entitled "A Multiple-Task Performance Battery Presented on a CRT"; Technical Report 3, entitled "Methodological and Operational Aspects of Programmed Environment Research"; and Technical Report 4, entitled "Extended Analysis of Small Group Performance and the Effects of Contingency Management in a Programmed Environment"). Additionally, reports of research conducted under the contract were presented in the following papers and publications in the open scientific literature:

Emurian, H.H., Emurian, C.S. and Brady, J.V. Effects of a pairing contingency on behavior in a three-person programmed environment. Presented at the annual convention of the Eastern Psychological Association, Boston, Mass., 1977.

Emurian, H.H., Emurian, C.S. and Brady, J.V. Effects of a pairing contingency on behavior in a three-person programmed environment.

Journal of the Experimental Analysis of Behavior, 1978, 29, 319-329.

Emurian, H.H., Emurian, C.S., Schmier, F.R. and Brady, J.V. Effects of an appetitive and an avoidance schedule on behavior in a three-person environment. Presented at the annual convention of the Eastern

Psychological Association, Washington, D.C., 1978.

Emurian, H.H. Enclosed environment observations. Symposium on Neurological Monitoring, Bowman-Gray School of Medicine, Winston-Salem, N.C., 1978.

Emurian, H.H. A multiple task performance battery presented on a CRT. JSAS Catalog of Selected Documents in Psychology, 1978, 8, 102.

Brady, J.V. A consent form does not informed consent make. IRB, 1979, 1 (7), 6-7.

Brady, J.V. Perspectives on research with human subjects. The Behavior Therapist, 1979, 2 (5), 913.

Brady, J.V. and Emurian, H.H. Behavior analysis of motivational and emotional interactions in a programmed environment. In H. Dientsbier and H.H. Howe (Eds.) Nebraska Symposium on Motivation, 1978. Lincoln: University of Nebraska Press, pp 81-122.

Emurian, H.H., Emurian, C.S., Schmier, F.R. and Brady, J.V. Notes on programmed environment research. JSAS Catalog of Selected Documents in Psychology, 1979, 9.

Emurian, H.H., Emurian, C.S., Schmier, F.R., Brady, J.V., Meyerhoff, J.L. and Mougey, E.H. Appetitive and avoidance schedule effects on behavior: A systematic replication. Presented at the annual convention of the Eastern Psychological Association, Philadelphia, Pa., 1979.

Emurian, H.H. Behavior analysis of motivational conditions in a programmed environment. Presented at the annual convention of the Association for Behavior Analysis, 1979.

Emurian, H.H. and Brady, J.V. Small group performance and the effects of contingency management in a programmed environment. JSAS Catalog of Selected Documents in Psychology, 1979, 9.

Ray, R.L., Emurian, H.H. and Wurster, R.C. COMOV: A program for the analysis of the relationship between two time-series. Behavior Research Methods and Instrumentation, 1980, 12 (4), 479-480.

Brady, J.V. and Jonsen, A.R. The evolution of regulatory influences on research with human subjects. In R.A. Greenwald, M.K. Ryan and J.E. Mulvihill (Eds.) Human Subjects Research: An Operational Guide for Institutional Review Boards. New York: Plenum Press, in press.

Emurian, H.H. and Brady, J.V. Strife aboard Skylab, strife in the laboratory: Functionally similar? Science, submitted.

Emurian, H.H. and Krausman, D.L. A computer program for a multiple task performance battery. Behavior Research Methods and Instrumentation, submitted.

Behavioral Program. Figure 1 presents a diagrammatic representation of a behavioral program exemplar governing, in general form, the sequential and contingent relationships among activities employed throughout the series of experiments to be summarized herein. Each box within the diagram represents a distinct behavioral unit and response requirement, and participants progressed through the program from left to right. This progression involved program branches composed of a fixed

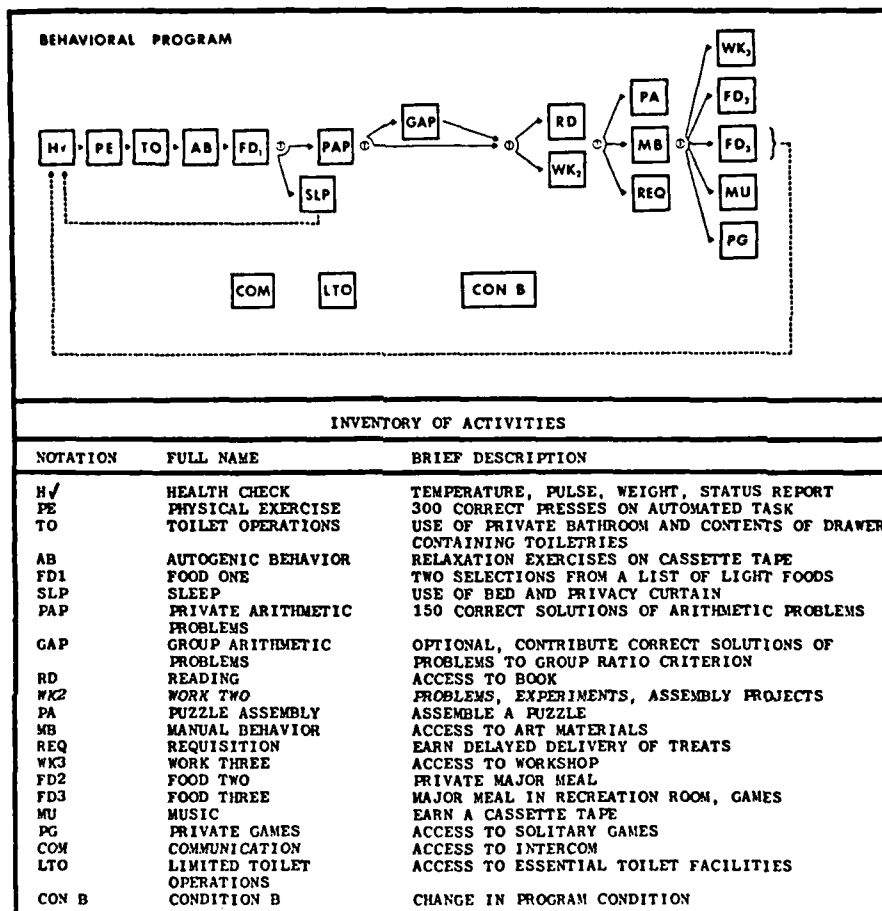


Figure 1. A diagrammatic representation of a behavior program exemplar governing, in general form, the sequential and contingent relationships among activities.

activity sequence and optional activity sequences. Regardless of the sequence selected, the diagram indicates that all behavioral units were scheduled on a contingent basis such that access to a succeeding activity demanded satisfaction of the requirements for the preceding unit. (See Technical Reports 1 and 3 for detailed descriptions of experimental applications involving such a behavioral program.)

Performance measures. A multiple-task-performance-battery (MTPB) was developed and incorporated into the research for assessment of group and individual performance effectiveness. Figure 2 presents a photograph of an MTPB console on which performance tasks were presented on a cathode ray tube (CRT) display terminal. This battery, which is described in detail in Technical Report 2, is composed of the following five task components which were presented concurrently to an operator.

(1) Blinking lights, providing a measure of watchkeeping. A signal changes position between two vertically arrayed displays at a baseline rate of twice per second. The operator is required to respond when the signal becomes fixed and flashes in either vertical position. A response by the operator restores the signal to baseline conditions. This task is presented to the right of center on the CRT terminal.

(2) Warning lights monitoring, providing a measure of vigilance. Within two vertically arrayed displays, a green light is extinguished in one display, and a red light is illuminated in the second display. The operator is required to respond to a red light, and a response extinguishes the red light and illuminates the green light. This task is

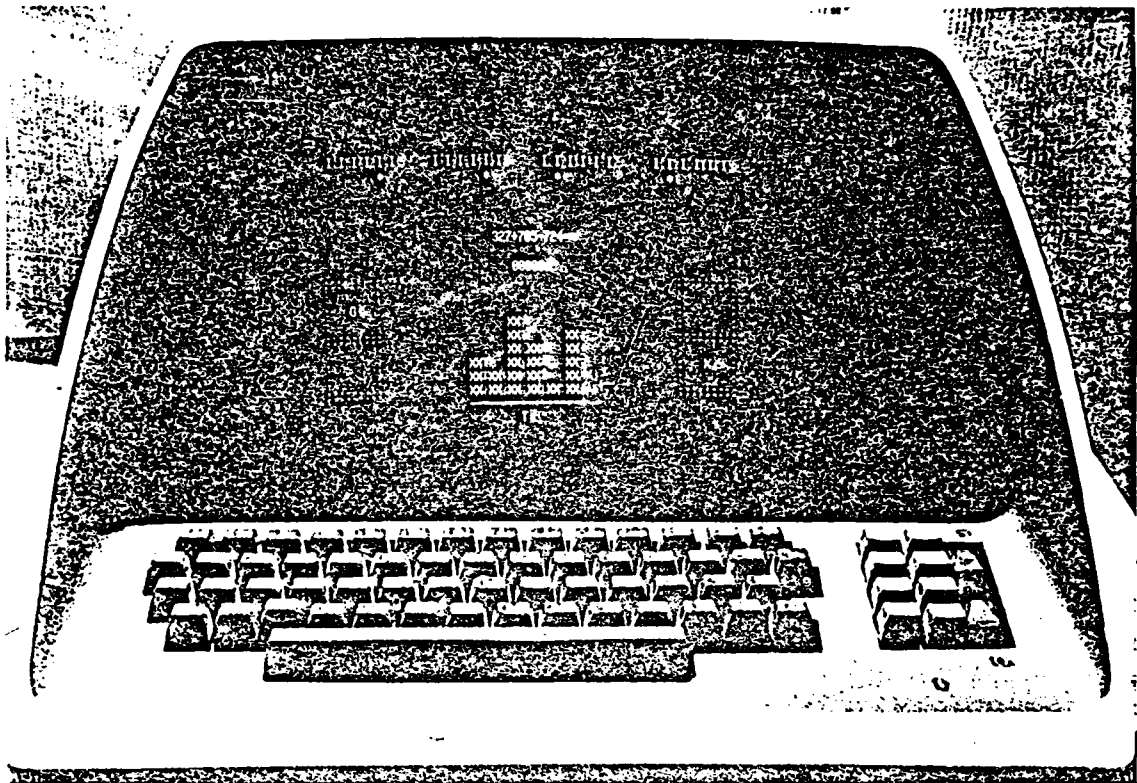


Figure 2. A photograph of an MTPB console.

presented to the left of center on the CRT terminal.

(3) Probability monitoring, providing a measure of attentive functions. On each of four separate and independent scales, a pointer exchanges position in such a way that the average scale value is the mid-scale position. At random intervals, a bias occurs such that the average pointer value, over time, is either to the left or to the right of the mid-scale position. The four scales are completely independent, the inter-bias-interval varies, and the duration of the bias varies. Additionally, the scale position that is omitted by the pointer during a bias is unsystematically distributed among all scale positions between successive bias conditions. A response by the operator while a bias is present restores the average pointer value to the mid-scale position. The probability monitoring task is presented at the top of the CRT terminal.

(4) Target identification, providing a measure of sensory-perceptual functions. An original histogram is presented within a 6 x 6 element matrix with its base at 6 o'clock and with no bar lengths repeated. The target histogram is erased, and two comparison histograms are presented successively. The comparison histograms appear with bases at 9 o'clock, 12 o'clock, or 3 o'clock. One of the comparison histograms may or may not duplicate the target histogram. The operator indicates whether the first, second, or neither of the comparison histograms was identical to the target. Target and comparison histograms are presented several times per minute. The target identification task is presented in

the center of the CRT display.

(5) Arithmetic operations, providing a measure of short-term and long-term memory functions. An arithmetic problem composed of three 3-digit numbers is presented on the screen. The problems are generated randomly with the restriction that answers must be 3-digit positive numbers. The solution requires summing the first two numbers and subtracting the third number from the sum. Calculations are performed without paper and pencil or other aids. The operator enters his answer and responds to lock it in for evaluation. Problems are presented at a rate of 2 per min, giving the operator 30 sec to enter a solution. The arithmetic operations task is presented below the target identification task on the CRT terminal.

Subjects. In response to recruitment notices placed in a local newspaper, male volunteers were accepted for participation in the research on the basis of psychological evaluation, educational background, and availability. Subjects were familiarized with the operational features of the laboratory, with the experimental methodology, and with the performance tasks during several daily sessions preceding an experiment, and informed consent was obtained. Remuneration was a function of a per diem allowance or work-task productivity and accuracy, and parameters were chosen such that each subject could earn approximately \$50 per day for completing the experiment.

Aversive motivational condition analyses. Six experiments were designed and conducted to compare the effects of appetitive and aversive

motivational conditions on individual and small group performance in a continuously programmed environment. The protocol for these studies provided a predetermined amount of remuneration for each completed "work unit" by individual team members in the form of a contribution to a group account, with group earnings divided evenly among the participants upon completion of the study. The objective of this innovative modification in the behavioral program was to generate a performance-consequence relationship between participants and experimenters superimposed upon the intrinsic motivational properties of the established behavioral schedule, and thereby to enhance the relevance of the studies to actual operational conditions. Under such circumstances, the experiments to be described focused upon an explicit analysis of the conditions under which these interrelationships between participants and experimenters influence performance effectiveness. One experiment was compromised by a total power outage of the programmed environment and a second was aborted by a participant immediately following the last orientation session. Data, then, are summarized for the four successfully completed experiments.

Although the basic fixed and optional components of the behavioral program as previously described continued to be in effect, for three groups (Groups 1-3) the following sequence of five work unit activities was made available independently of the remaining sequentially arranged activities: (1) Private Arithmetic Problems (PAP), requiring 200 correct solutions; (2) Work One (WK1), requiring 5000 lever operations; (3) Arithmetic Problems (AP), requiring 50 correct solutions; (4) Physical Exercise (PE), requiring 500 correct presses; and (5) Health Check (H✓),

requiring completion of the health assessment battery. The work unit was programmed for concurrent availability in each private room, and it could be selected upon completion of any activity within the full behavioral program. Once a work unit had been selected, all five activities had to be completed before the subject could resume the behavioral program at the location where the work unit was voluntarily initiated. During a work unit, the Communication activity was unavailable, and subjects were not permitted to use the tape player for music. Parameters were chosen so that completion of a work sequence required 1-1.5 hours.

For Group 4, much more sophisticated performance requirements were introduced in place of the work-unit sequence. A room in the programmed environment was dedicated as a duty station which contained computer peripheral devices displaying the multiple-task-performance-battery (MTPB) that determined on-duty performance. Since only a single operator could be present in the assigned area, this duty station format fostered around-the-clock operation of the performance battery and accordingly simulated situations requiring a group to be continuously operational with respect to critical mission demands. Parameters were chosen so that the accumulation of 600 MTPB accuracy points required 1-1.5 hours.

The consequences of completing the various work tasks were systematically varied to assess the effects of alternative work performance-consequence relationships between the participants and the experimenters. Throughout the first several days of a mission, a positive, i.e., appetitive, relationship was in effect whereby group

members' completion of a work unit or MTPB points produced deposits to a group account, the proceeds of which were equally divided among the participants at the conclusion of the study. Throughout the next several days of a study, a negative, i.e., avoidance, relationship was in effect such that work no longer produced increments in the group account, but rather was required of the participants in order to avoid withdrawals of similar magnitude. That is, work performance requirements for avoidance days provided that withdrawals be made from the group account for uncompleted work below an assigned daily total, e.g., 20 units or 10,000 MTPB points, determined on the basis of the group productivity records during the first several days, i.e., the average number of work sequences or MTPB points completed in 24 hours. This group requirement could be satisfied under any condition of individual work scheduling or distribution decided upon by the participants. Finally, the last days of a study were programmed as a reversal to those conditions in effect during the first several appetitive days of the study, with the exception of Group 2 noted below.

For Groups 1 through 4, the appetitive (AP) and avoidance (AV) conditions were in effect in the following order and number of successive days under each condition, respectively: AP-AV-AP (4,4,3), AP-AV-AP-AV (3,3,3,3), AP-AV-AP (3,6,3), and AP-AV-AP (2,3,1).

The performance-consequence contingency maintained substantial overall productivity levels for all subjects in each group within the course of the several studies. In Groups 1-3, no member completed fewer

than two work units per day with a range of 2 to 16 units. In Group 4, whose members operated the performance battery, the range of daily productivity levels, at least when all participants worked, was 2000 to 5684 points, representing approximately 3 to 9 hours of work.

Within Groups 1-3, the work unit outputs were more evenly distributed among subjects during the avoidance condition in comparison to such distributions during the appetitive condition. A comparison of the differences between the highest and lowest work unit frequency for all subjects within these groups, under the assumption that such differences approach zero when variability is absent, between the two conditions showed a significant effect ($t=2.07$, $df=28$, $p<.05$). These distributions were a function of social pressures, to be explained below, by high-productivity individuals who were intolerant of output variations among group members during the avoidance condition.

Group 4 was the only group which had a member who failed to work during a 24-hour period. Table 1 presents total MTPB points earned by each subject in Group 4 across successive days of the experiment. On day 5, the second day of the avoidance condition, a crisis occurred within this group which not only resulted in "mutinous" withdrawal from duty by a subject, but also threatened the group's capacity to complete its mission, i.e., completion of the assigned daily work. On that second day of the avoidance condition, Subject 3 fell behind in his typical performance productivity by a magnitude of less than 2 percent of the assigned daily group criterion. Unlike a high-productivity subject's

TABLE 1
TOTAL MTPB POINTS PER DAY
Successive Days

Subject	Appetitive Days No Criterion		Aversive Days Criterion=12700			Appetitive Day No Criterion
	1	2	3	4	5	6
1	4154	4221	4388	4627	0	5648
2	3927	4381	4437	4810	2450	5023
3	2000	4126	3966	3207	3755	4487

tolerance of variations in productivity during the appetitive condition, this subject (Subject 1) became openly and vehemently hostile at this relatively trivial shortcoming, and he displayed verbal aggression toward his teammates. Importantly, Subject 1 refused to perform any further work during the avoidance condition, although the duration of the avoidance condition was not known by the group, and on day 5, the group lost heavily in potential earnings as a result of insufficient personnel to operate the duty station on a continuous and efficient basis.

Disruption in group cohesion during the avoidance condition was not limited to Group 4. During each Health Check activity, each subject responded on a 4-point scale reflecting "degree of irritation" (1=none to 4=extreme) with the other two participants. Intermember expressions of irritation during avoidance conditions were most pronounced in Group 1 and Group 4. Significantly, in both of these groups, crisis situations were related to a member whose productivity levels, at least during the avoidance conditions, were somewhat less than those of his teammates. In Group 1, Subject 2, the low-productivity member, was rejected by the group on day 7, the third day of the avoidance condition, and he was isolated from social interactions for the remaining days of the study. Importantly, despite these crisis situations observed during the avoidance conditions, group members in both Groups 1 and 4 showed reduction in at least expressed interpersonal irritation when the appetitive condition was reintroduced as the final phase of the study.

The results with Group 4, in which a participant failed to work on

day 5, confirm and extend the outcomes of the previous three evaluations of avoidance schedules and they further suggest that where performance requirements are continuous, realistic, and demanding under such conditions, a group may fail to complete its assigned mission. However, although the experimental protocol provided for only one appetitive day to follow the avoidance condition in Group 4, this brief period was sufficient to reveal partial recovery of group cohesiveness and individual productivity on the duty station. Intermember tensions declined, and the mutinous team member was reintegrated into the performance schedule, resuming his previous productivity levels. Significantly, performance productivity and on-duty performance effectiveness for Group 4 were highest during the last appetitive day of the study, as they were for Group 1.

The expressed opinions and emotional attitudes of the group directed to the behavioral program and to the experimenters differed significantly between the appetitive and avoidance conditions. During each Health Check activity, each subject responded on a 4-point scale reflecting "degree of irritation" (1=none to 4=extreme) with the behavioral program and the experimenters. With respect to the behavioral program, all subjects in each group showed the highest daily ratings during the avoidance condition, and for a pooled analysis, mean ratings were significantly higher during the avoidance condition in comparison to corresponding ratings of the appetitive condition ($t=9.47$, $df=114$, $p<.001$). With respect to the experimenters, seven of the twelve subjects showed the highest daily ratings during the avoidance condition, and for

a pooled analysis, mean ratings were significantly higher during avoidance conditions in comparison to corresponding appetitive conditions ($t=2.72$, $df=117$, $p<.01$). In effect, then, the avoidance condition produced emotional displeasure with the behavioral program and with the experimenters who were perceived as responsible for allowing this aversive work situation to continue.

With respect to the more intra-personal aspects of these program condition effects, subjects reported mood changes between the program conditions on the Depression factor of the Lorr's Mood Scale which was also administered during each Health Check activity. Eleven of the twelve subjects showed the highest daily rating during the avoidance condition, and for a pooled analysis, mean depression ratings were significantly higher during avoidance conditions in comparison to corresponding appetitive conditions ($t=3.95$, $df=117$, $p<.001$). Finally, the observed recovery to pre-avoidance levels of such mood ratings during the final appetitive days of a study (Group 2 was the exception), where extraordinary work output was observed, substantiates the fact that high productivity itself need not be a cause of dysphoric mood or strained subject-experimenter interactions.

Performance on the several component tasks of the work unit was not differentially influenced by the two program conditions. With few exceptions, all performance measures showed small, but consistent, improvements throughout the course of the studies. Similar performance trends were observed on the components of the MTPB for Group 4, and Table

2 present these data for Subjects 1, 2, and 3 respectively, across several consecutive half-hour observational intervals. One such interval occurred during the second half hour of work when a high performance probe was in effect such that signal or task misses and errors produced a substantial reduction in accuracy points. Throughout the remaining intervals of work, total duration of which was determined by the operator's preference, only false alarms diminished accuracy-point accumulations.

These data from Group 4 show that all tasks within the battery were performed by each subject during any given interval presented. Additionally, errorless performance was never observed, showing that the battery and its associated parameters continued to challenge the subjects even after many hours of practice. However, performance accuracy was sensitive to the demands of the high performance probe (HPP). During the HPP, all subjects showed an increase in the frequency of false alarms on the probability monitoring task (D), perhaps the most difficult task in the battery to operate correctly. Furthermore, Subjects 1 and 3 showed a striking increase in failures to respond (i.e., signal misses) on the target identification task (T). In summary, then, MTPB performance accuracy was not differentially affected by the two program conditions, although its vulnerability to change, if not disruption, was revealed by the performance decrements observed during the high performance probe.

Group Composition Analyses. The next two experiments were designed and conducted to assess the effects on individual and group behavior of a

TABLE 2

		MTPB PERFORMANCE DATA FOR SUBJECT 3																			
		P				A				T				W				B			
		M	H	FA	L	R	W	H	L	R	W	H	L	M	H	FA	L	M	H	FA	L
AP	I.	33.3	6.0	21.3	46.8	55.7	3.3	1.0	14.2	21.0	5.3	2.0	88.0	1.7	1.3	1.1	29.7	3.3	0.7	10.7	
	II.	49.0	4.7	59.0	35.7	53.0	5.3	1.7	15.3	7.0	1.7	19.3	87.0	1.0	0.7	1.1	34.3	1.7	1.0	9.1	
	III.	33.0	8.0	19.7	45.5	55.0	4.0	1.0	14.0	22.0	2.3	3.7	80.7	1.0	0.0	1.1	32.0	3.3	1.3	9.7	
	IV.	47.7	2.7	25.0	47.2	57.0	3.0	0.3	14.5	24.7	3.0	0.7	83.7	1.3	0.3	1.1	33.7	1.3	0.3	9.1	
	Mean	43.3	5.6	31.3	43.6	55.2	3.9	1.0	14.5	18.7	3.1	6.4	84.8	1.3	0.6	1.1	32.4	2.4	0.8	9.7	
AV	I.	44.2	5.0	23.3	43.9	56.0	3.7	0.3	12.6	22.5	4.0	1.5	87.8	0.0	0.5	1.0	35.0	1.0	0.8	7.4	
	II.	56.5	0.3	81.7	27.7	56.0	3.8	0.0	13.9	7.2	4.2	20.2	88.0	0.2	0.2	1.0	36.8	1.3	1.5	7.2	
	III.	43.4	5.8	31.4	42.6	53.8	4.8	0.8	13.1	20.8	4.8	2.4	85.8	1.0	0.7	1.0	35.6	1.6	1.2	7.1	
	IV.	45.2	4.8	27.2	41.8	56.8	3.2	0.0	12.7	23.2	4.6	0.2	89.8	0.0	0.0	1.0	36.4	1.0	0.8	6.2	
	Mean	47.8	4.0	40.9	39.0	55.7	3.9	0.3	13.1	18.4	4.4	6.1	87.9	0.3	0.3	1.0	36.0	1.2	1.1	7.0	
AP	I.	45.5	5.5	13.5	43.8	56.5	3.5	0.0	12.3	23.5	3.5	1.0	81.5	1.0	0.5	1.0	34.0	1.0	2.0	6.3	
	II.	59.0	0.5	81.0	24.7	52.5	6.0	1.5	14.0	7.5	1.0	19.5	92.0	0.5	0.5	1.0	36.5	0.5	1.5	6.9	
	III.	39.5	9.5	25.5	41.7	56.5	3.5	0.0	12.4	18.0	6.0	4.0	87.5	1.0	0.0	1.0	42.0	0.0	0.5	6.0	
	IV.	42.0	6.5	26.0	39.5	57.5	1.5	0.0	12.2	21.0	5.0	2.0	91.5	0.0	0.5	1.1	36.0	0.0	0.5	5.7	
	Mean	45.5	5.3	37.8	37.4	55.8	3.6	0.4	12.7	17.5	3.9	6.6	88.1	0.6	0.4	1.0	37.1	0.4	1.1	6.2	

Legend: P=probability monitoring, A=arithmetic operations, T=target identification, W=warning light monitoring, B=blinking light monitoring, H=hits, M=misses, FA=false alarms, L=latency in sec, R=right, and W=wrong. I=first half hour, II=second half hour of high performance probe, III=third half hour, and IV=last half hour of work. AP=appetitive condition means, and AV=avoidance condition means.

third participant's introduction into and withdrawal from a previously established and relatively stable two-person social system. The objective of the first such study was to focus upon (1) the social mechanisms and temporal properties associated with the integration of such a participant into the established group, and (2) sources of group disruption and/or cohesiveness fostered by his presence. The second study incorporated procedural changes (1) to extend the previous analysis to a somewhat different set of experimental conditions, and thus (2) to demonstrate the reliability and generality of previous results.

The first two-person group resided for ten days within the continuously programmed environment. After several days under dyadic conditions, the third participant was introduced into the programmed environment. His instructions were to follow the rules of the behavioral program which were almost identical to those for the other two participants. The only difference was related to the consequences of work. The third participant was permitted to operate the performance battery, but his accuracy points were deposited in the joint account for the other two participants. These variables were deliberately left free to vary so that triadic social activities and work distributions, including the third participant's contributions, could be related to (1) the overall status of the social system as affected by the presence of the third participant, and (2) the processes by which he was integrated into the group. After several days under such triadic conditions, the third participant was withdrawn from the group, and the original two-person group remained for several additional days.

The dyadic (D) and triadic (T) conditions were in effect in the following order and number of successive days under each condition, respectively: D-T-D (3,4,3).

Results showed that the two-person group adopted a pattern of work and rest that persisted throughout the course of the experiment. Over half of the daily work was typically completed before 6 PM, at which time a social episode almost always occurred, and the remaining work was completed after 9 PM. Only on Day 1 did the participants fail to reach a ceiling imposed on work, and on the other days the duty station was occupied for approximately 12 man-hours per day, and the ceiling was reached. Shortly after the introduction of the third participant on Day 4, an extended intercom communication occurred, initiated by him, with all three participants simultaneously engaged in the Communication activity. The duration of this particular communication episode exceeded the duration of all other such episodes within the dyadic and triadic conditions. Thus, the third participant's integration into the group began immediately upon his arrival, and the content of the episode amounted to a "briefing" by the two full-time participants on the events and experiences during the preceding days in the environment.

The work schedules changed throughout the course of the triadic condition. The third participant commenced working for the other two group members on the first day of his arrival, and he continued working on each successive day thereafter. On a daily basis, this participant showed a gradual increase in total accuracy points earned, until on the

last day of his participation, the work was evenly divided among the three group members. This suggests that several days were required for reinforcement processes other than remuneration to affect the work performance of the third participant, and that such processes were sufficiently powerful to result in no difference in work productivity among the three participants on the final day of the triadic condition.

Social activity durations changed between the dyadic and triadic conditions. The briefest social activity duration always occurred during the dyadic condition, and conversely, the longest duration always occurred during the triadic condition. Additionally, a social episode occurred on each day of the experiment with the exception of the absence of a dyadic episode on Day 2. Since triadic social activities were generally longer than dyadic ones, the third participant contributed to the reinforcing properties of the episode. This suggests that the triadic contingency facilitated the third participant's integration into the group and that the resulting triadic episodes contributed to the reinforcement mechanisms maintaining the third member's work.

The program synchrony exhibited by the two full-time participants changed when the third participant was introduced. For the dyad, synchrony increased on Day 4 of the experiment and remained relatively constant throughout the duration of the triadic condition. On Day 8 when the third participant was removed, synchrony gradually declined over days to a terminal level similar to that observed during the first dyadic condition. Finally, the magnitude of triadic synchrony during the

triadic condition exceeded the magnitude of dyadic synchrony during both dyadic conditions. These effects show the strength of triadic social opportunities as reinforcers, and they further suggest that triadic social interactions contributed to the maintenance of the third participant's work productivity.

Analyses of testosterone levels obtained from total 24-hour urine volumes collected throughout the experiment showed changes by the two-person group (Subjects 2 and 3) when the third participant (Subject 1) was introduced and withdrawn. When Subject 1 was introduced on Day 4 of the study, testosterone levels initially fell for Subjects 2 and 3, and showed a gradual recovery over successive days. When Subject 1 was withdrawn on Day 8, testosterone levels for the 2-person group were thereafter similar to those observed during the first three days of the study. An analysis of absolute testosterone levels showed that Subject 1 produced a daily amount toward the upper boundary of normal testosterone limits, whereas Subjects 2 and 3 showed a lesser daily amount. These levels relate directly to pre-experiment psychometric data in that Subject 1 scored highest on the personality trait "Dominance" (16PF), whereas Subject 3 scored the lowest on this trait.

In the second experiment of this series, the two-person group resided for ten days within the continuously programmed environment. Unlike the previous study, there was no ceiling on accuracy points, and access to the performance battery was continuously available. After several days under dyadic conditions, the third participant was

introduced into the programmed environment. His instructions were to follow the behavioral program rules which were identical to those for the other two participants, at least for the duration of this triadic condition. These rules stipulated that only two subjects could operate the duty station during any 24-hour period. These "working" subjects accumulated accuracy points for themselves, whereas the "resting" subject was awarded the average earnings of the other two for that day. Working and resting subjects were not predetermined, and team members decided among themselves who these individuals would be at the beginning of each day of the triadic condition. After several days under such triadic conditions, the third participant was withdrawn from the group, and the original two-person group remained for several additional days. The dyadic (D) and triadic (T) conditions were in effect in the following order and number of successive days under each condition, respectively: D-T-D (3,4,3).

Results showed that shortly after the introduction of the third participant at the beginning of Day 4, an extended intercom communication occurred, initiated by him, with all three participants simultaneously engaged in the Communication activity. The duration of this particular communication episode exceeded the duration of all other such episodes within both dyadic and triadic conditions. Thus, the third participant's integration into the group began immediately upon his arrival, and the content of the episode included a "briefing" by the two full-time participants on events and experiences during the preceding days in the environment. These results are strikingly similar to those of the

previous experiment, and they suggest a constancy of process whereby interpersonal information is sought and shared during the initial reorganization of an established social system.

The content of this initial communication also revealed the team members' concern with work. Significantly, the established two-person group was notably resistant to relinquishing the work assignment, even though each member had worked for three successive days, and neither member would have been disadvantaged by resting since all subjects were trained to the same level of performance effectiveness prior to the onset of the experiment. Of at least equal significance was the novitiate member's pressure to begin work on that first day of the triadic condition, although he, too, would not have been disadvantaged by resting. Since the novitiate member did finally agree to rest on that first day of the triadic condition, after repeatedly exhorting the other Subjects to let him work, this result shows an important resistance of an established group to change, even when such change would result in freedom from duty. They also show the influence that the two-person group had on the novitiate team member under conditions which placed no ceiling on earnings for performance productivity.

Total work productivity was not significantly affected by the opportunity to work and rest on successive days of the triadic condition. Furthermore, the third participant worked on only two of the four triadic days, and each of the other team members rested on only one day. Examination of daily diaries and social activities revealed no change in

the nature of the group interactions during the triadic condition. Whereas team members reported that triadic social episodes were highly rewarding, the two-person group appreciated more the interpersonal camaraderie which emerged during dyadic episodes, especially those which occurred during the last days of the experiment.

Analyses of testosterone levels obtained from 24-hour urine volumes collected throughout the experiment revealed predictably direct relationships with behavioral and psychometric outcomes as compared to the relationships observed within the preceding study. For Subjects 1 and 2, who composed the 2-person group, levels of testosterone were consistently within the upper average limits, but the levels for Subject 3, who was introduced and withdrawn from the environment, were clinically diminished. Significantly, Subject 3 was permitted to work on only two of the four triadic days, and he also showed the lowest value on the personality trait "Dominance" (16PF). Taken together, these observations suggest a potential mechanism for predicting the degree of reorganization and interpersonal adjustment to be anticipated when an established social system is joined by a highly dominant or submissive individual.

The third experiment was designed to assess further the effects on individual and group behavior of a third participant's introduction into and withdrawal from a previously established and relatively stable two-person social system. This systematic replication of the two previous studies focused upon the social and performance effects associated with the integration of such a participant into the

established group and upon sources of group disruption and/or cohesiveness fostered by his presence. Particular experimental attention was also directed to participants' hormonal (e.g., testosterone) levels in relationship to the programmed changes in group membership. The replication involved procedural innovations intended (1) to extend the previous analyses to a somewhat different set of experimental conditions with novitiate participants, (2) to potentiate the outgroup status of the third participant who joined the ongoing two-person group, (3) to provide baseline hormonal values for the novitiate, and (4) to demonstrate the reliability and generality of previous results.

The two-person group resided for ten days within the continuously programmed environment. Participants followed a behavioral program of contingently scheduled activities which determined individual and social behaviors, the latter being available on a non-cooperative basis throughout the study. Separate from the behavioral program was access to a work station containing a multiple task performance battery (MTPB) and a serial (SL) learning task. Accurate operation of the MTPB and SL task produced "accuracy points" which were deposited in a joint account to be divided evenly between the two ten-day participants at the conclusion of the experiment, and which determined remuneration for participation.

After four successive days under such dyadic conditions, the third participant was introduced as a member of the group. For three preceding days, this third participant had resided in a private chamber, but his

behavioral program lacked communication, social, and work opportunities. This three-day period provided a hormonal baseline against which to evaluate the effects of joining the group. During the next four three-person group days, the novitiate participant was required to operate the MTPB and SL tasks for his individual remuneration, whereas he was paid a fixed per diem on baseline "alone" days. At the conclusion of this four-day period, the third participant left the group for a final two-day baseline period within his private room while the established group returned to its status as a two-person team. The dyadic (D) and triadic (T) conditions were in effect in the following order and number of successive days under each condition, respectively: D-T-D (4,4,2).

Results showed that the intersubject program synchronization exhibited by the two-person group changed when the third participant was introduced. For the two-person group, synchrony values were lower during triadic days (range: 4.17% to 0.42%) than during corresponding dyadic days (range: 22.4% to 1.3%). These data suggest a potentially disruptive influence on a previously established and harmonious living and work routine when a new participant must be accommodated into the existing schedule.

The contingencies of reinforcement associated with work appeared to impact upon potential social interactions available during the triadic condition. The third participant engaged in a 28-minute social episode on Day 5, the first day of the triadic condition, and he voluntarily remained alone on successive days of the experiment. The two ten-day

participants socialized with one another on six of the ten days (two of which occurred during the triadic condition), and their social durations were briefer during triadic days in comparison to dyadic days. These data suggest that the individual work contingency programmed for the third participant potentiated his outgroup membership status which was reflected in the diminished frequency of social contact with other team participants.

Two of the three participants showed notable changes in androgen (testosterone) output, assessed from analyses of total urine volume collected throughout the experiment, as a function of the two-person and three-person conditions. These data are presented in Figure 3 which presents micrograms of testosterone across successive experimental days for all subjects in this group (identified as "Group 1"). A ten-day participant, Subject 2, whose basal testosterone values were low in comparison to standardization parameters, showed increases in testosterone output when the third participant was introduced into the group, and his values declined during the final two two-person days of the study. Significantly, this participant was the only group member expressing irritation with the novitiate member as determined from interpersonal ratings obtained during the Health Assessment activity. The novitiate participant, Subject 3, who was introduced into the group on day 5, showed a marked suppression of testosterone during the four three-person days, with a recovery to baseline levels during his last two solitary days of the experiment. Additionally, the steep decline in testosterone by Subject 1 over the first four dyadic days of the study

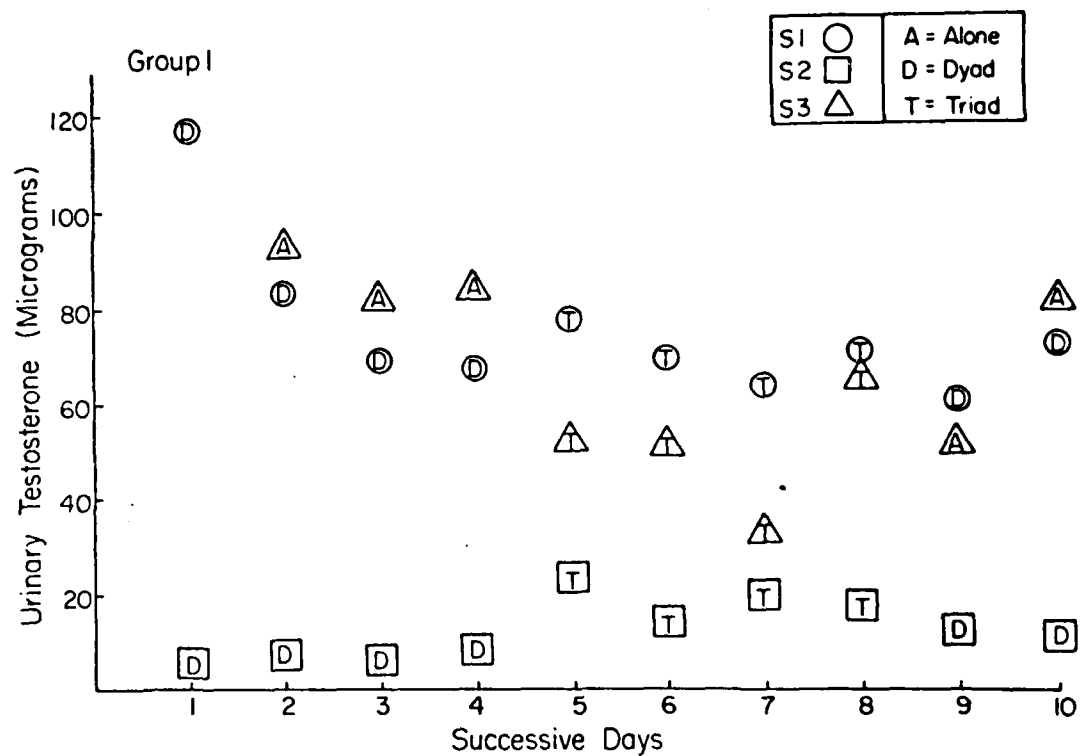


Figure 3. Micrograms of testosterone for all subjects across successive days of the experiment.

may reflect an active process in response to the initial organization of the two-person group. These data suggest that the organization of a social system and its subsequent reorganization impacted upon central nervous system activity as revealed by corresponding changes in testosterone output among team participants.

The fourth experiment systematically replicated the three previous studies involving a change in group composition and size with particular experimental attention directed to participants' hormonal (e.g., testosterone and cortisol) levels in relationship to such programmed changes. In comparison to the previous studies in this series, however, the present replication involved procedural changes intended (1) to provide basal hormonal levels prior to dyadic and triadic group formation and (2) to demonstrate the reliability and generality of previous results under conditions of an intersubject replication.

In addition to dyadic and triadic social conditions to be described, the experiment was composed of baseline and work days. On baseline days, subjects followed a behavioral program in their private quarters, but without access to work, intercom communications, or social activities. During such baseline days, subjects received a per diem allowance. On work days, subjects also followed a behavioral program which included social activities and intercom communications, and they were additionally required to operate the multiple task performance battery for their earnings.

The two-person group participants resided for ten successive days

within the continuously programmed environment. Days 1-3 were solitary baseline days, and on day 4, these participants formed a two-person team with competitive work opportunities. That is, a participant's MTPB accuracy-point earnings were deposited within his individual account which was awarded to him at the conclusion of the experiment. This two-person work condition was in effect from days 4-6. Also on day 4, the novitiate participant began his baseline days within his private quarters, remaining under such conditions from days 4-6. On day 7, the novitiate participant joined the previously established two-person team. Days 7-10, then, were triadic days with all three participants operating the performance battery on a competitive basis. In summary, the design of this experiment allowed assessment of androgen productivity and behavioral factors under baseline conditions which preceded dyadic team formation and triadic team reorganization.

Results showed that the programmed changes in group size and composition were clearly related to changes in androgen productivity. These data are presented in Figure 4 which presents total urinary testosterone across successive experimental days for all subjects in this group (identified as "Group 2"). Subjects 1 and 3, the two ten-day participants, show intermediate testosterone levels throughout the first six dyadic days of the experiment. The levels are comparable to those exhibited by the novitiate, Subject 2, throughout alone days 4-6. When the novitiate participant joined the group on day 7, his testosterone levels at least doubled, and these substantially elevated levels persisted throughout the course of the experiment. In contrast,

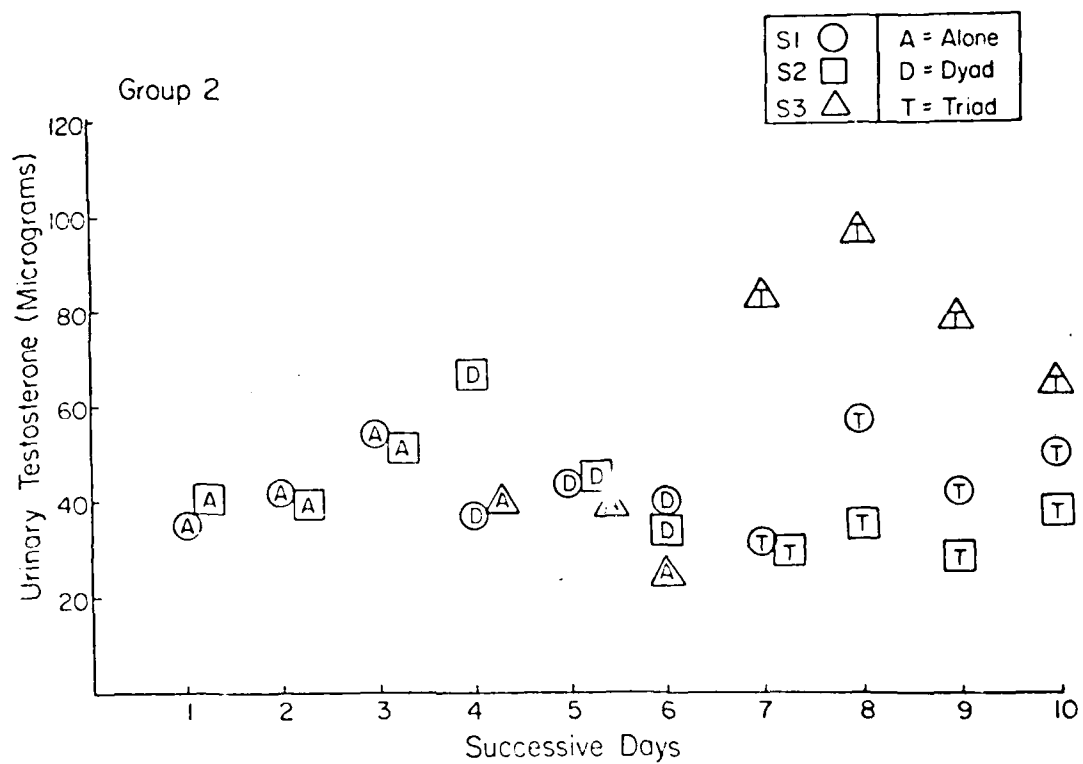


Figure 4. Micrograms of testosterone for all subjects across successive days of the experiment.

testosterone levels of the two ten-day participants dropped when the novitiate joined the group, and only Subject 1 showed a recovery to those levels observed throughout the six preceding dyadic days. Taken together, these observations show the impact on the endocrine system of basic social processes of group formation and reorganization, and they suggest the importance of an appreciation of potential behavioral-biological interactions as they may affect the status of members of a confined microsociey.

In "Group 1", the novitiate participant unsuccessfully defended (i.e., unsuccessfully maintained) his baseline wake-sleep cycles during subsequent work days, and his testosterone was observed to decrease during the triadic condition. In "Group 2", the novitiate participant successfully defended (i.e., maintained) his baseline wake-sleep cycles during subsequent work days, and his testosterone was observed to increase during the triadic condition.

In summary, when a novitiate individual was introduced into an established group, his urinary testosterone increased or decreased over baseline values in relationship to his success or failure to gain access to a work station according to a schedule that was least disruptive to his previous wake-sleep routine. Although the experimental design does not permit conclusions about cause and effect relationships, the results clearly show that testosterone output is sensitive to a change in environmental conditions and may be an expression of a more general class of behaviors reflecting patterns of dominance and submissiveness. The

importance of these relationships are to be understood in terms of providing a conceptual and methodological framework for the analysis and prediction of differential effects of team turbulence on individual and social behaviors and on performance effectiveness.

Ancillary observations. In addition to the studies reported above, three complimentary and preliminary analyses were conducted within the compass of the overall research program. One study involved a comparison of effects of competitive and cooperative motivational conditions on individual and group performance. A second study involved an analysis of effects on performance of a restricted behavioral program. A third study involved the assessment of sustained skilled performance under conditions of fixed work intervals (e.g., 8 hours) for each volunteer participant. The results of these analyses were utilized in the selection of optimal performance and behavioral program parameters as reflected in the reported series of investigations, and they contributed valuably to the overall research program objectives.

PROJECT SUMMARY

A research program was undertaken to study the effects of motivational factors and social interactions on small-group performance effectiveness within the framework of an experimental analysis of behavior as observed in a continuously programmed environment. Within the context of such an analysis, investigations were conducted to isolate by-products of aversive control and to demonstrate alternative scheduling conditions which are free from such deleterious effects. Related

motivational analyses were conducted to determine the effects on individual and group performance of a change in the size and membership of an established team unit. The significance of this research is to be understood in terms of the emerging motivational and social-interaction principles having direct relevance to the establishment and maintenance of operational team performance effectiveness.

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